DOCUMENT RESUME

ED 021 700 24 RE 001 401

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THE ROLE OF STIMULUS STRUCTURE IN THE PERCEPTION OF BRIEFLY EXPOSED VISUAL STIMULI. FINAL REPORT.

Wisconsin Univ., Madison.
Spons Agency- Office of Education (DHEW), Washington, D.C. Bureau of Research.
Report No- PROJ-3293
Bureau No- BR-5-0603
Pub Date Mar 68
Contract- OEC-6-10-286
Note- 31p.
EDRS Price MF-$0.25 HC-$1.32
Descriptors- MEMORIZING, *PERCEPTION, *REDUNDANCY, *VISUAL STIMULI, WORD RECOGNITION, *WRITTEN LANGUAGE

Experiments within the microgenetic paradigm provide an assessment of the role of stimulus structure and, inferentially, of cognitive structure on perception. Two experiments investigating the effect of redundancy (structure) in written language on visual perception are reported. Seven-letter arrays differing in percentage of redundancy were repeatedly exposed for brief durations. The arrays were unfamiliar to the subjects in experiment 1. The subjects had to memorize the list of stimuli in experiment 2. All subjects were instructed to report what they saw. Perceptual "reports" (Natsoulas, 1967) were obtained in experiment 2 only. A third experiment was run to check the results of experiment 2. Letter position was the overriding determiner of perceptibility, yielding an inverted U-shaped function about the fixation point. The increase in perceptibility as a function of stimulus structure was significant, but small. Information transmitted decreased markedly. The results are interpreted in relation to two models of information flow for the recognition and microgenesis tasks. References are listed (Author/BS)

BR-5-0603
PA-24

FINAL REPORT

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March, 1968

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Final Report

Project No. 3293

Contract No. OE-6-10-286

The Role of Stimulus Structure in the Perception of Briefly Exposed Visual Stimuli

Maurice Hershenson

University of Wisconsin

Madison, Wisconsin

March, 1968

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SUMMARY

Experiments within the microgenetic paradigm provide an assessment of the role of stimulus structure and, inferentially, cognitive structure, on perception. Seven-letter arrays differing in % redundancy were repeatedly exposed for brief durations. The arrays were unfamiliar to the Ss in Exp. I whereas the Ss had to memorize the list of stimuli in Exp. II. All Ss were instructed to report what they saw. Perceptual "reports" (Natsoulas, 1967) were obtained in Exp. II only. Letter position was the overriding determiner of perceptibility, yielding an inverted U-shaped function about the fixation point. The increase in perceptibility as a function of stimulus structure was significant but small while information transmitted decreased markedly. The results are interpreted in relation to two models of information flow for the recognition and microgenesis tasks.

Tachistoscopic recognition and perceptual microgenesis provide contrasting paradigms for the study of the effects of past experience on perception. While the stimuli are repeatedly exposed for brief durations in both paradigms, no change is made in the parameters of stimulation in the microgenesis paradigm, whereas duration or intensity is usually varied in the recognition paradigm. In both tasks, performance improves over repeated exposures of the stimulus.

The important difference between the two tasks, however, is not the differential treatment of the stimulus, but the instruction given to the viewer. In the recognition paradigm S is instructed to guess, i.e. to report what he thinks the stimulus was, while in the microgenesis paradigm, S is instructed to report what he saw. Thus the two tasks clearly involve both perceptual and memory processes, but the difference in instructions suggests that different processes predominate in determining the response: memory for the recognition task and perception for the microgenesis task. Since the relative contribution of the two processes has never been evaluated for these "perceptual" tasks, some confusion remains as to the locus of the effects of past experience. Does it affect the percept, taking part in the perceptual processing, or does it only affect the report of the percept, entering the system as part of the subsequent memory processes?

Miller, Bruner, and Postman (1954) interpreted the improvement in recognition with familiarity of context which they found for letter arrays as support for the view that the perceptual process was altered. However, they provided no means for separating perceptual from memory processes so that the locus of their effect could not be determined. Indeed, Baddeley (1964a) found the same relationship when exposure time was long enough for S to have perceived all of the letters in the stimulus. He suggested, therefore, that the effects were initiated in postperceptual processes. This was a forceful hypothesis because now the corollary finding--that the amount of information processed per exposure was constant--could be seen as a reflection of the limitation of immediate memory. In this view, the more closely a letter sequence approximates English, the easier it was to encode in terms of existing language habits, and the better it was remembered and reproduced. But Baddeley's experiment does not eliminate the possibility that similar effects exist in the perceptual system and that Miller, et al. were, in fact, observing such a phenomenon.

The microgenetic paradigm provides less ambiguous data: other things being equal, briefly exposed English words were more easily perceived than Turkish words (Hershenson & Haber, 1965). The interpretation of this finding required two assumptions: (1) stimulus structure was controlled to the extent that the languages have unique but equivalent letter probabilities and sequential dependencies, and (2) past

experience with language in the form of cognitive structures--S's stored equivalent of the structure in the language--was available to S only for English. The greater perceptibility of English over Turkish words could then be attributed to the differential availability of cognitive structures related to the two languages. The emphasis on report of what was "seen" in that experiment suggested that memory entered the processing sequence prior to visual experience and affected the visual image.

The two experiments to be reported were performed to examine this effect of cognitive structure in more detail: to pinpoint the locus of the effect and to quantify it. To this end, stimulus structure was varied by using letter arrays differing in approximation to English (AE) as well as English words, while cognitive structure, that structure represented by S's knowledge of the English language, was assumed to be constant. The contribution of cognitive structure to the percept could then be assessed, presumably, by assessing the role of stimulus structure since it has already been demonstrated that the structure in the stimulus is of little use unless mediated by its counterpart in memory (Hershenson & Haber, 1965). Moreover, using stimuli varying in AE permits measurement of stimulus information and subsequent calculation of the amount of information processed in a purely perceptual task.

Method

Experiment I

Stimuli.--Seventy English words were randomly selected from those of Haber and Hershenson (1965). In addition, four lists of seventy 7-letter arrays of each of zero-, first-, second-, and third-order AE were constructed according to a procedure outlined by Shannon (1948). Each stimulus array was lettered in black on a white card. The letters were 3/8 in. high, 2 1/2 in. wide, and subtended a horizontal visual angle of 2 1/2°. The reflectance, measured at the eyepiece with a Macbeth Illuminometer, was 95 m-L. for both stimulus and adapting fields. (The same value was obtained with a Pritchard Photometer, Model No. 1970-PR, some months after the experiment.) In all other respects the stimuli conformed to those of Haber and Hershenson (1965).

Procedure.--Ten arrays in each of the stimulus lists were randomly assigned to each of seven (1, 2, 3, 4, 5, 10, and 15) exposures (E) representing the number of times it would be flashed. Five random presentation orders were constructed containing two arrays randomly assigned to each of the 35 cells of an AE-by-E matrix. The presentation orders followed a random sequence for each S.

The stimuli were presented in one channel of a three-channel mirror tachistoscope (Scientific Prototype Mfg. Corp., Model GA). A second channel, serving as an adapting field, contained two faint lines demarking the

area in which the arrays would appear. The Ss were instructed to fixate between two faint dots which bisected the lines. The S initiated each trial by pressing a button when he was giving maximal attention to the proper fixation point.

The Ss were given two practice sessions preceding the experiment. English words with one letter missing were flashed so that S's performance could be monitored via reports of missing letters. Few incorrect responses were made. The durations to be used for each S in the experiment proper were determined during these practice sessions by adjusting the exposure duration of the practice words until a value was found such that S reported few letters on the first exposure but correctly reported all the letters (and the correct missing letter) on some subsequent exposure. The mean duration was 12 msec.; the range was from 9 to 20 msec.

In all experimental sessions, S reported after each exposure both the letters he was certain he perceived and their respective positions (P) even when, in the case of English words, he was certain of the word. At no time was S given information as to his accuracy. Nor did he know at the time he was reporting whether there would be further exposures for the same array. Interflash interval was never less than five seconds.

Subjects.--The Ss were 11 male undergraduate students enrolled in an elementary course in perception at the University of Wisconsin. They had not previously served in a perception experiment and were not aware of the nature of the experiment at the time of testing. Each S was tested individually in seven 1-hour sessions.

Experiment II

Except for those which spelled English words, the letter arrays in Exp. I were unfamiliar to the Ss. But clearly S had to remember what he saw in order to report it. Thus, it could be argued, despite the effort to ensure that Ss reported only what they saw, it would be possible for the reports to be altered by nonperceptual factors operating subsequent to the visual image. Moreover, since the stimuli differed in AE, a differential ability to remember the letter arrays as a function of AE could also be reflected in the responses. Thus it would be impossible to determine whether the differences were due to activity in the perceptual system or not. To eliminate this ambiguity, a second experiment was performed in which Ss were required to memorize the entire list of letter arrays.

Stimuli.--The stimuli were 65 arrays, 13 from each of the five lists of Exp. I. Because of an alteration in the apparatus, the arrays were relettered slightly smaller in height (5/16 in.) using a slightly different lettering stencil (LeRoy No. 3240-240C and pen No. 3233-5). All other parameters of stimulation were unchanged.

Procedure.--Each S was given a set of cards containing the 65 arrays to memorize at his leisure. When S felt he had committed the list to memory, he was tested in the tachistoscope to determine whether he could recall each array after a brief exposure. A duration was selected (less than 10 msec.) for which S would report seeing only one or two letters of a seven-letter array. Each array was presented at this duration and S was required to spell it out. When S was able to reproduce over 95% of the letters in all of the arrays, he was permitted to begin the experiment proper.

During the test sessions it was also possible to determine a duration at which S reported two or three letters per exposure. These durations, ranging from 4 to 30 msec. with a mean of 20 msec., were used in the experiment proper.

The 65 arrays were each exposed five times according to ten independently constructed random orders. These orders were sequenced randomly over ten days so that all Ss tested on the same day (never more than three) received the same list on that day. Since Ss started the experiment on different days, no two Ss received the same sequence of random lists, i.e., the random order of lists and experimental days on which a particular S would receive the lists were uncorrelated.

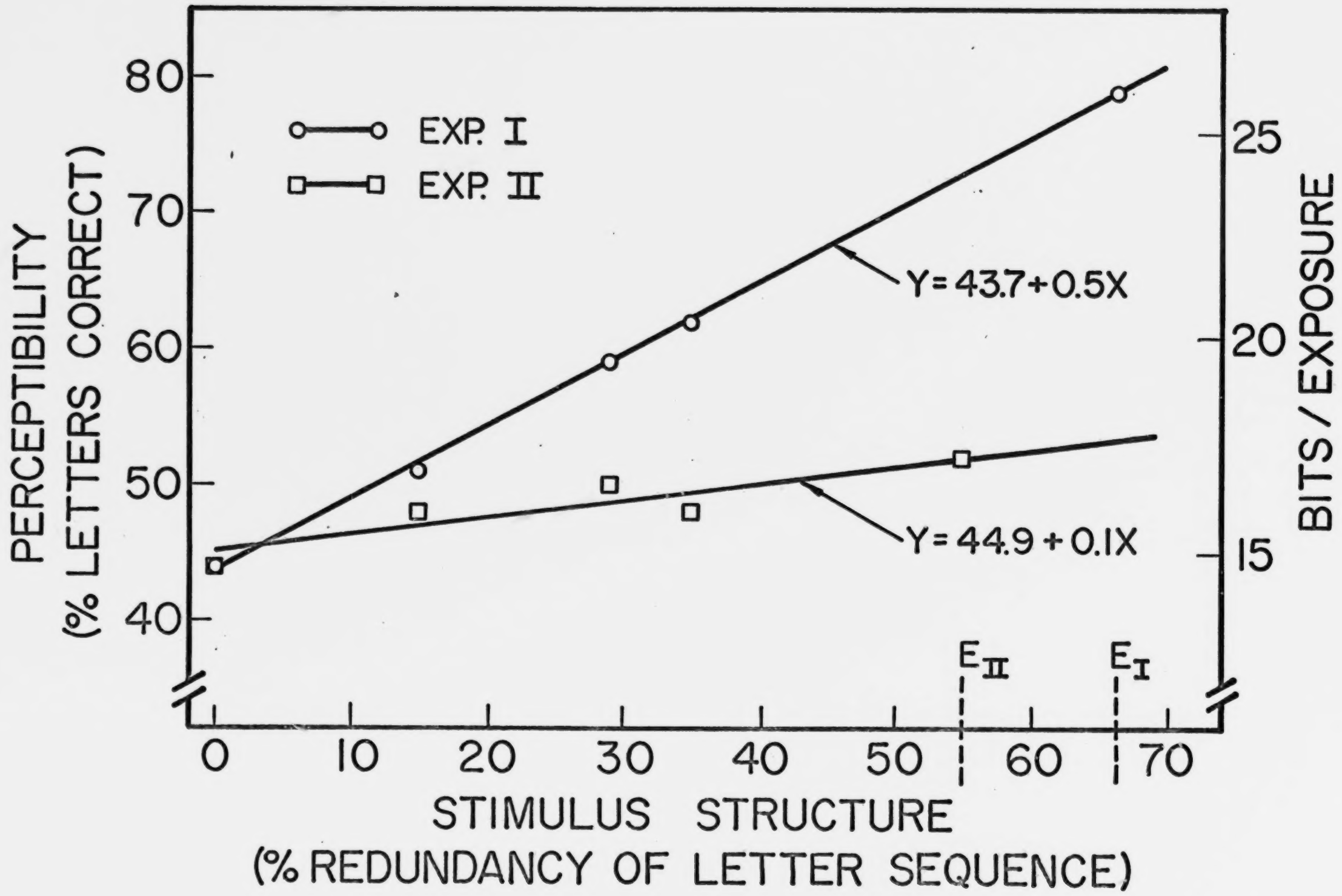
The Ss were given prior knowledge of the stimulus array to be flashed by exposing it in the tachistoscope while S spelled it out. This procedure, together with complete learning of the stimulus population, was intended to eliminate any effect of differential forgetting for arrays of different AEs (Haber, 1965) and to ensure perceptual report (Natsoulas, 1967). In all other ways the procedure was the same as in Exp. I.

Subjects.--The Ss were six graduate and undergraduate students and the author. Each S was tested individually in ten 1-hour sessions. Three Ss were familiar with the procedure, the remainder were naive.

Results

A four-way factorial analysis of variance was performed on arc sine transformations of proportions (% letters correct) for the first five exposures of Exp. I, and for Exp. II. All main effects and interactions were significant ($p < .01$) except the AE x E interactions in Exp. I and the AE x E and AE x E x P interactions in Exp. II. All of the subsequent analyses refer to these data.

Stimulus structure.--Figure 1 shows that perceptibility, measured by percent letters correct, increased as a function of stimulus structure, measured by percent redundancy of letter sequences, for both experiments.

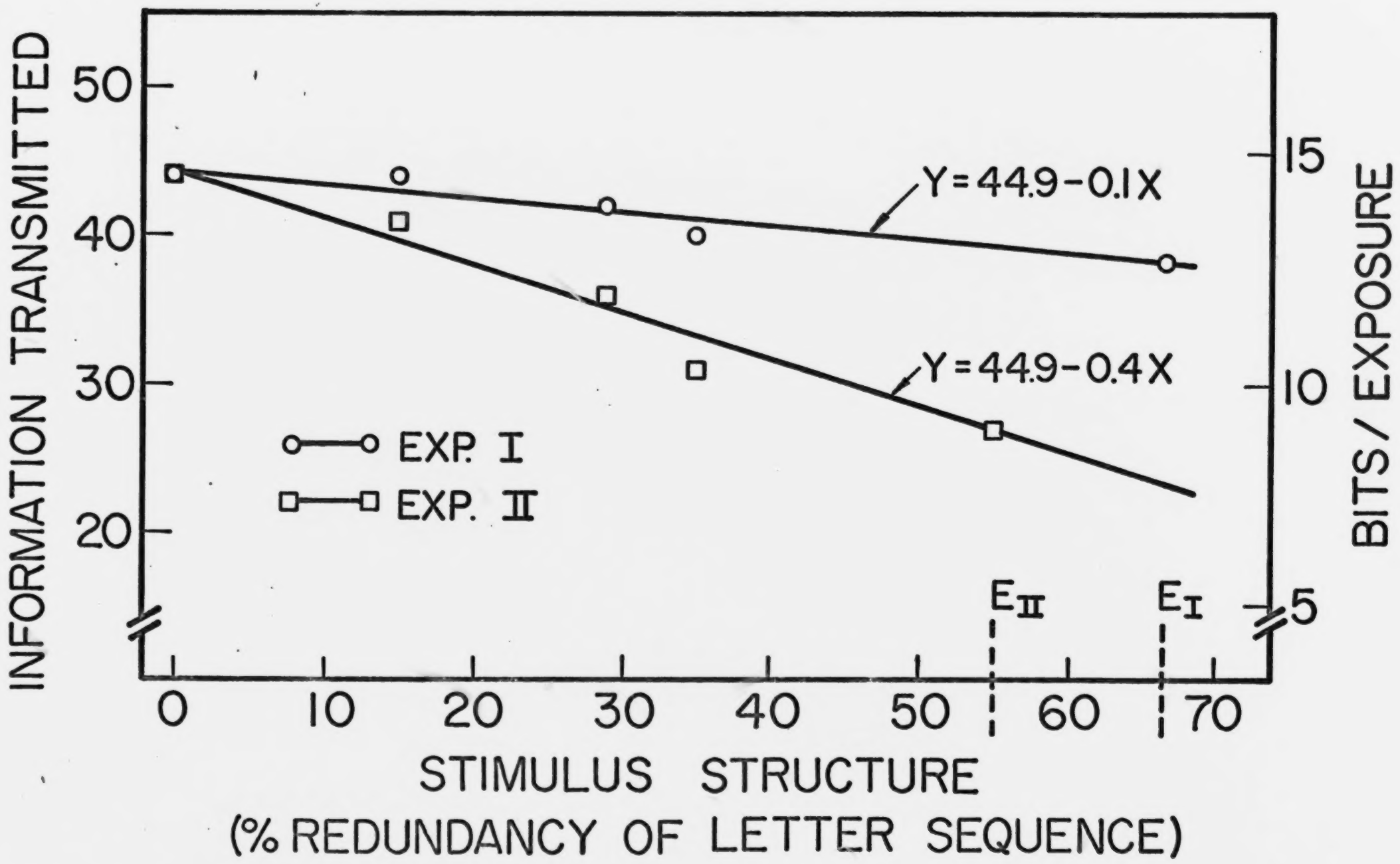

EXP. I
EXP. II
Y = 43.7 + 0.5X
Y = 44.9 + 0.1X
PERCEPTIBILITY
(% LETTERS CORRECT)
BITS / EXPOSURE
80
70
60
50
40
25
20
15
0
10
20
30
40
50
60
70
E_{II}
E_{I}
STIMULUS STRUCTURE
(% REDUNDANCY OF LETTER SEQUENCE)

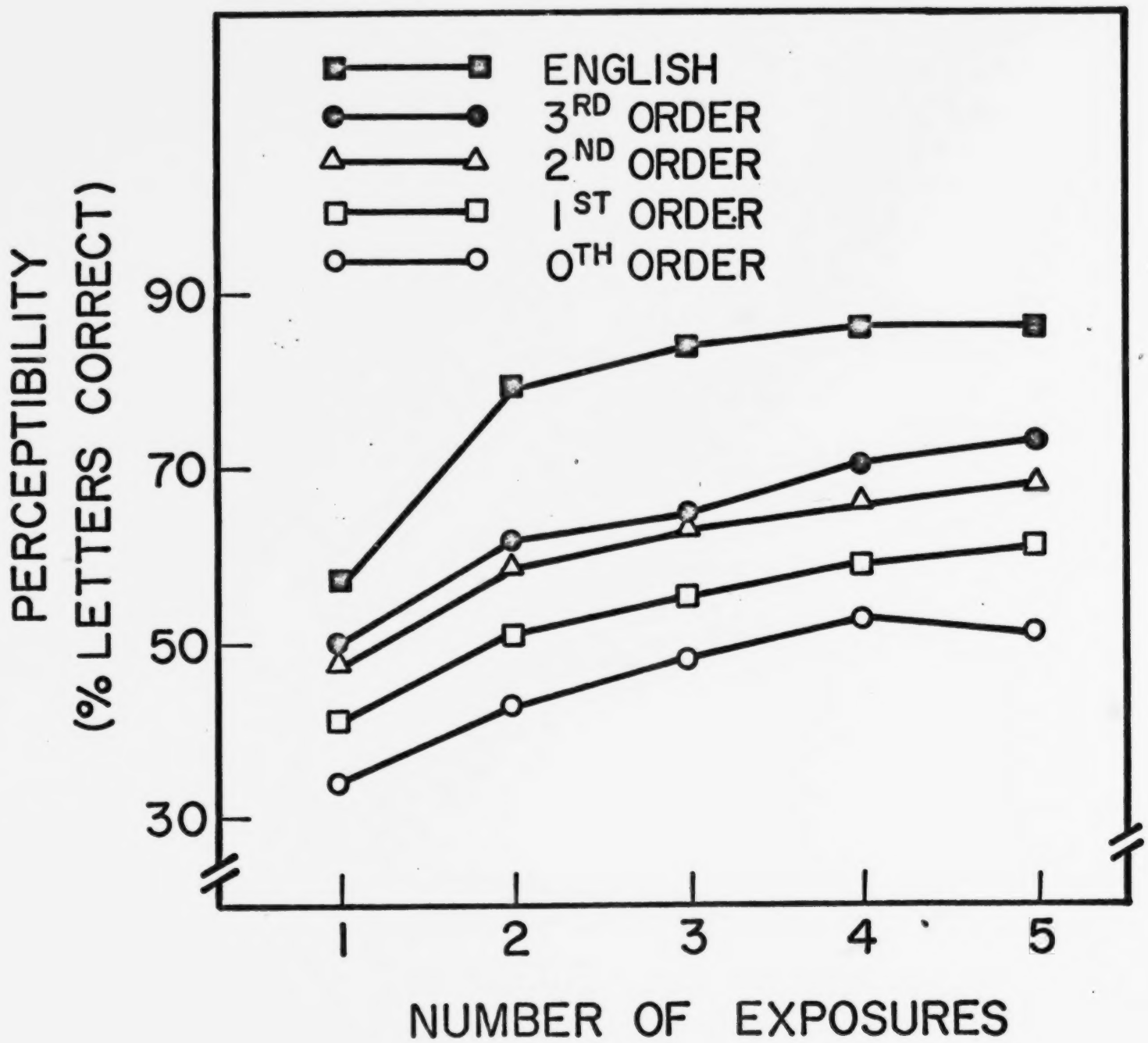
The percentages are also shown transformed into bits per exposure according to the following rationale: Since no statistical constraint exists between the neighboring letters or in the selection of letters in the zero-order arrays, each letter represents one equally likely selection out of 26, requiring, on the average, $\log_2 26 = 4.71$ bits per letter. Since each array contains seven letters, there are $7 \times 4.71 = 32.97$ bits available on each exposure for zero-order arrays. The amount of information perceived, in bits, is given by the product of this value and the percentage associated with the corresponding value of information perceived.

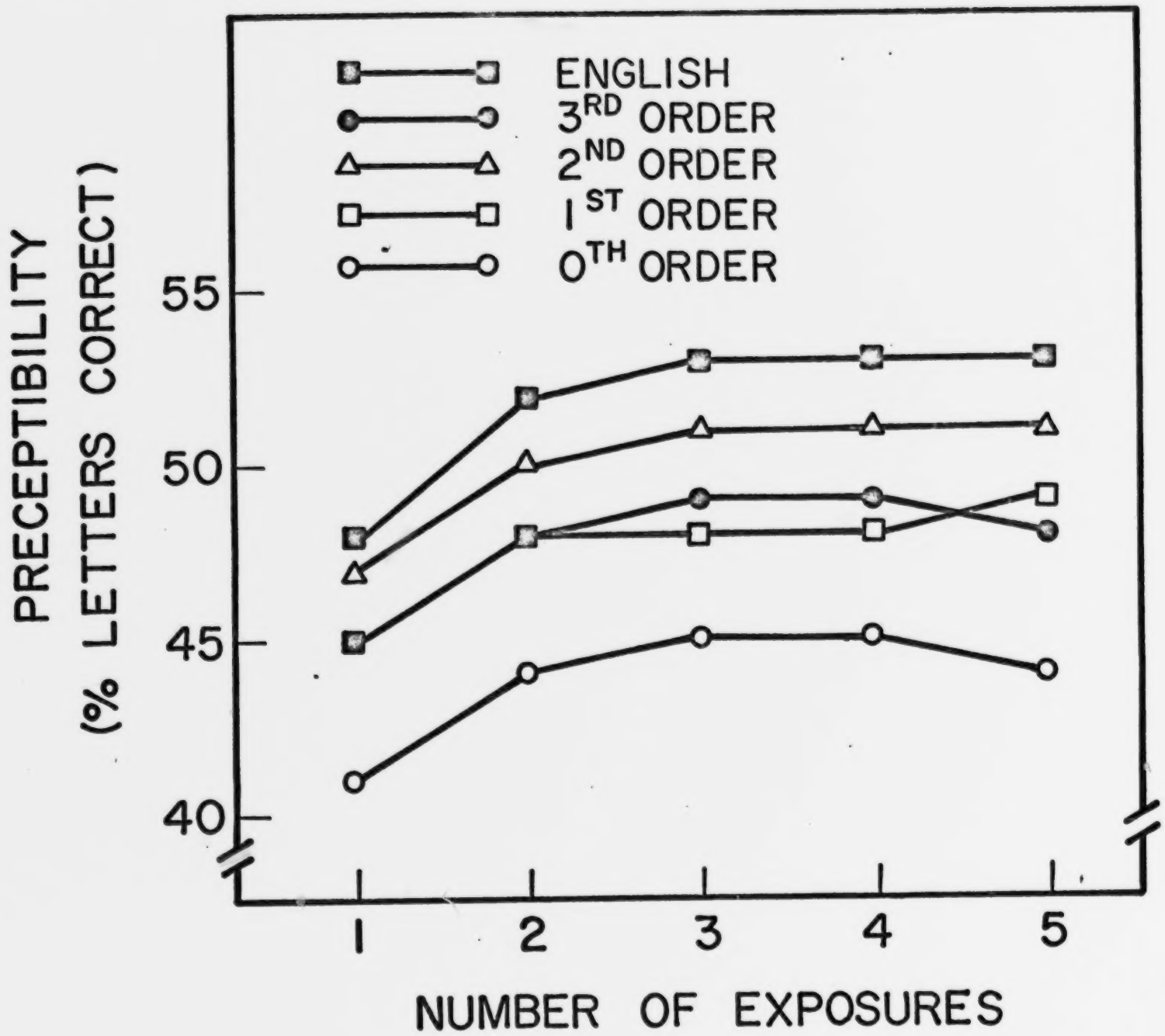
For each experiment, the line of best fit was calculated by the method of least squares using only the data from zero-, first-, second-, and third-order AE because fairly precise estimates of percent redundancy are available for these letter sequences (Baddeley, 1964b; Miller, et al., 1954; Tulving, 1963). The values used throughout this report are: zero-order = 0% redundancy, first-order = 15% redundancy, second-order = 29% redundancy, and third-order = 35% redundancy. The point for English was then plotted at the abscissa value corresponding to the obtained perceptibility score. This method yielded redundancy estimates for English of 67% for Exp. I and 55% for Exp. II. The latter value is consistent with other estimates of the redundancy of printed English (Garner, 1962, p. 239).

Information transmitted (processed) per exposure as a function of stimulus structure is shown, for both experiments, in Figure 2. Information transmitted is calculated by taking account of the relative redundancy of the stimuli, i.e., by correcting the perceptibility scores (% letters correct) for the redundancy arising out of the statistical constraints used to construct the stimuli. Thus information transmitted = (information perceived) - (correction for redundancy of stimulus) = (% letters perceived) x (100 - % redundancy). This correction underlies the conclusion of Miller, et al. (1954) and of Baddeley (1964a) that the amount of information transmitted per exposure is independent of the redundancy of the stimulus. Figure 2 shows that there was a linear relationship between information transmitted and stimulus structure in both experiments, but both lines have a negative slope. Thus in the microgenesis situation, the more highly structured the stimulus, the less the information transmitted per exposure.

Repeated exposures.--Perceptibility increased over repeated exposures for each AE in a more or less parallel fashion up to the fourth exposure in Exp. I (Fig. 3). Perceptibility for the fifth exposure did not differ from that for the fourth (Newman-Kuels test). Perceptibility was also scored in percent "words" (all seven letters) correct for each of the fifteen exposures. These data compare favorably with other measurements of the microgenetic increase in perceptibility over repeated exposures which were scored in this way (Haber, 1966, 1967). In Exp. II the effect of repeated exposures (Fig. 4) was negligible after the second exposure (Newman-Kuels test).


INFORMATION TRANSMITTED
50
40
30
20
BITS/ EXPOSURE
15
10
5
Y=44.9-0.1X
Y=44.9-0.4X
EXP. I
EXP. II
E II
E I
0
10
20
30
40
50
60
70
STIMULUS STRUCTURE
(% REDUNDANCY OF LETTER SEQUENCE)


ENGLISH
3RD ORDER
2ND ORDER
1ST ORDER
0TH ORDER
PERCEPTIBILITY
(% LETTERS CORRECT)
90
70
50
30
1
2
3
4
5
NUMBER OF EXPOSURES


ENGLISH
3RD ORDER
2ND ORDER
1ST ORDER
0TH ORDER
PERCEPTIBILITY
(% LETTERS CORRECT)
55
50
45
40
1
2
3
4
5
NUMBER OF EXPOSURES

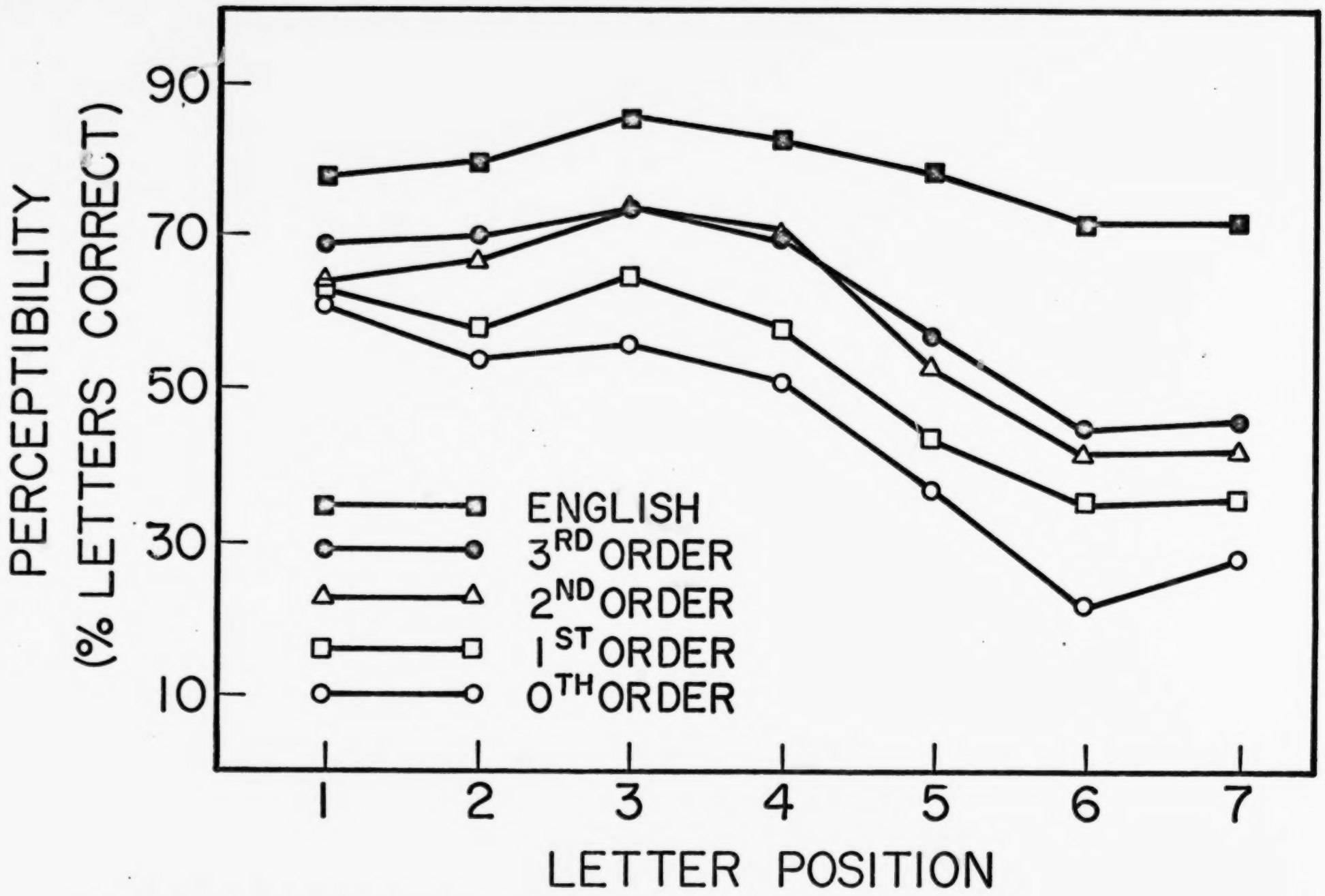
Letter position.--Perceptibility as a function of letter position appears to have been a combination of a number of factors in Exp. I. In general, the letter in the third position (the one just to the left of fixation) was perceived most often. The letters to the left of fixation were perceived more frequently than those to the right of fixation, and the end letters (positions 1 and 7) were perceived more frequently than their immediate neighbors. The linear, F (1, 10) = 41.52, $p < .01$; cubic, F_c (1, 10) = 32.41, $p < .01$; and quartic, F_q (1, 10) = 25.69, $p < .01$ trends for letter position were all significant.

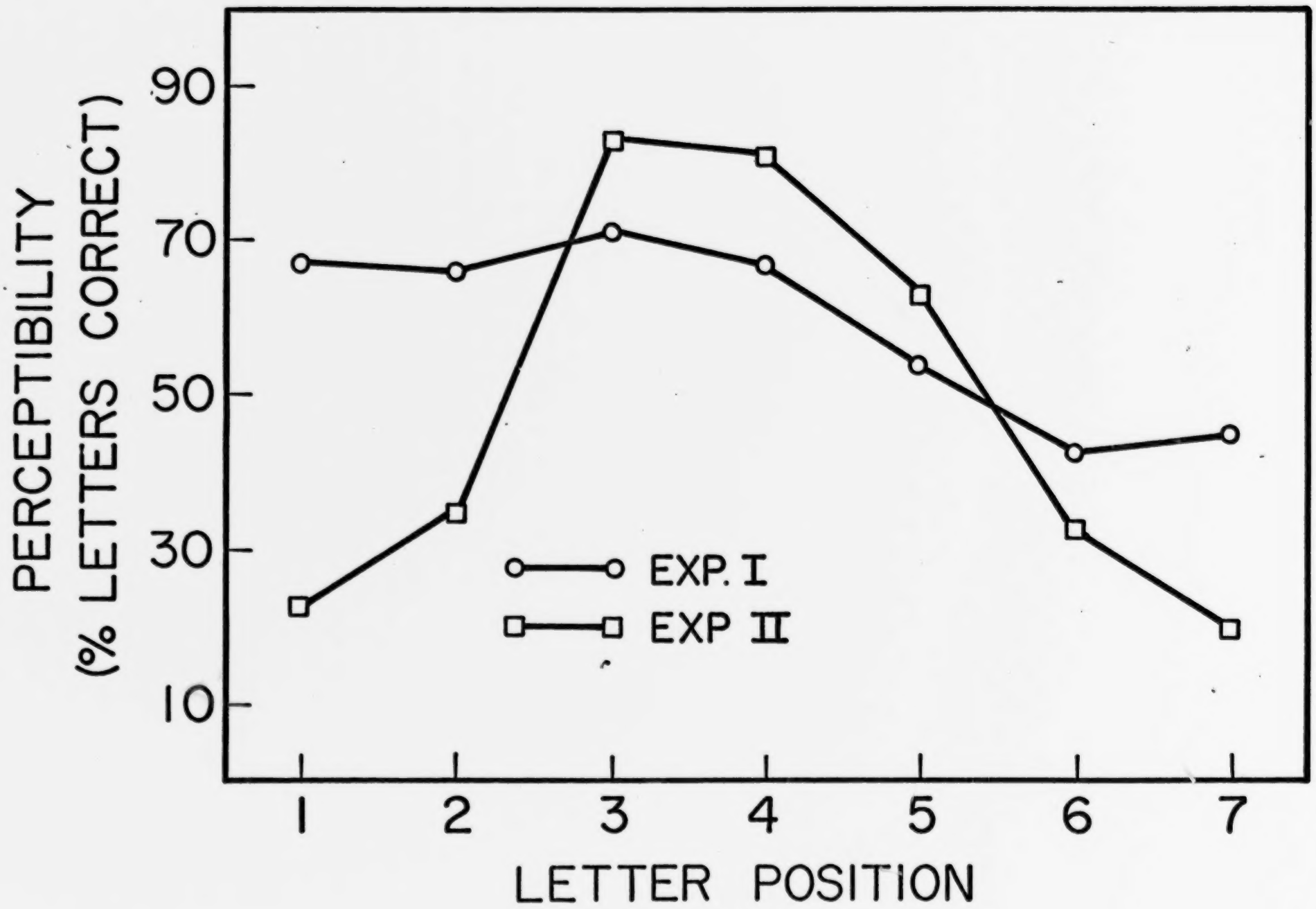
Letter position interacted with both AE and E. Figure 5 shows the differential position effect for AE. With respect to position, the curve for English is the most nearly symmetrical, while the zero-order curve shows a marked left-to-right decrease. The curves for the other AEs fall in between. This interaction probably reflects the differential forgetting over positions (the left-right decreasing linear trend) for the different AEs. It is most likely an order-of-report effect since the Ss invariably reported the letters from left to right although they were not instructed to do so. Further evidence that differential forgetting was involved is given by the E x P interaction which shows that performance over repeated exposures improved more with additional exposures for positions 5, 6, and 7.

Perceptibility was again a function of letter position in Exp. II but presented a markedly different picture from that of Exp. I. Figure 6 shows the comparative functions: the curve for Exp. I masks a great deal of spread among the AEs (see Fig. 5) whereas the curve for Exp. II is highly representative (the overlap was too great to present the separate curves pictorially). The overall effect is more sysmetrical in Exp. II: the quadratic, $F(1, 6) = 43.47$, $p < .01$, and quartic, $F(1, 6) = 17.97$, $p < .01$, trends were significant. The AE x P interaction, while significant, did not show a clear or marked relationship.

The E x P interaction in Exp. II also did not reflect large differences in the shape of the position curve but showed small consistent differences in the differential shift in letter perceptibility with increasing exposures for the different positions. Perceptibility decreased over the first three exposures and then increased slightly for positions 1, 2, and 3, while the opposite was true for positions 4, 5, 6, and 7.

Response analysis.--To analyze the properties of the responses in Exp. I, three frequency distributions were obtained for each AE x E cell: (a) letters correctly perceived (e.g., the number of times "A" was given in response to A in the stimulus), (b) stimulus letters confused or incorrectly perceived (e.g., the number of times A was presented when the response was some letter other than "A"), and (c) letters guessed (e.g., the number of times "A" was the response but not the stimulus). The three distributions were essentially summations of portions of a confusion matrix mapping stimuli along the columns into responses


PERCEPTIBILITY
(% LETTERS CORRECT)
90
70
50
30
10
ENGLISH
3RD ORDER
2ND ORDER
1ST ORDER
0TH ORDER
1
2
3
4
5
6
7
LETTER POSITION


PERCEPTIBILITY
(% LETTERS CORRECT)
90
70
50
30
10
EXP. I
EXP II
1
2
3
4
5
6
7
LETTER POSITION

along the rows: Letters correct is given by the diagonal entries, letters confused is the sum of the off-diagonal column entries, and letters guessed is the sum of the off-diagonal row entries. Thus there were three types of distributions for each of the 25 AE x E cells, yielding 75 distributions in all. The distributions of letters correct and letters confused were converted to percentages since all letters were not presented an equal number of times. The 75 distributions were intercorrelated (Pearson product-moment) within exposures. Only those correlations among the "guess" distributions were significant (mean r = 73.8, SD = 17.7).

Partial correlation coefficients were computed for each of the 75 distributions with five other distributions: objective visual confusability (VCO) from Chase and Posner (1965), subjective visual confusability (VCS-1) from Tinker (1928) and (VCS-2) from Chase and Posner (1965), auditory confusability (AC) from Conrad (1964), and English Frequency (EF) from Fitts and Switzer (1962). For the 75 distributions, none of the correlations with AC or with VCS-2 were significant, two of the correlations with VCS-1 were significant, and seven of the correlations with VCO were significant. Thus in Exp. I, there was little or no relationship between either the letters correctly perceived, the stimulus letters incorrectly perceived, or the letters guessed, and visual or auditory confusability.

The correlations with EF provide a clear pattern with respect to letters guessed. All entries were positive and significant except for zero-order and these were in the same direction and narrowly missed significance. Thus the distributions of incorrect responses were similar to that of EF--the Ss, when they made errors, responded as if they were guessing by sampling from a distribution of EF (Attneave, 1953).

Five of the 25 distributions of letters correct showed significant correlations with EF, the other 20 showing no clear pattern. All of the correlations but one between EF and letters confused were negative (16 significantly so) suggesting a tendency to confuse the less frequent letters in English. Thus, the letters correctly perceived had little relationship to the statistical properties of English, whereas the errors were directly related to these properties.

An analysis of errors was impossible to perform on the data of Exp. II since the Ss almost exclusively reported correct letters or nothing. The distribution for letters correct showed no consistent patterns.

Discussion

The two experiments investigated whether redundancy (structure) in written language contributes to visual perception. The analysis of the

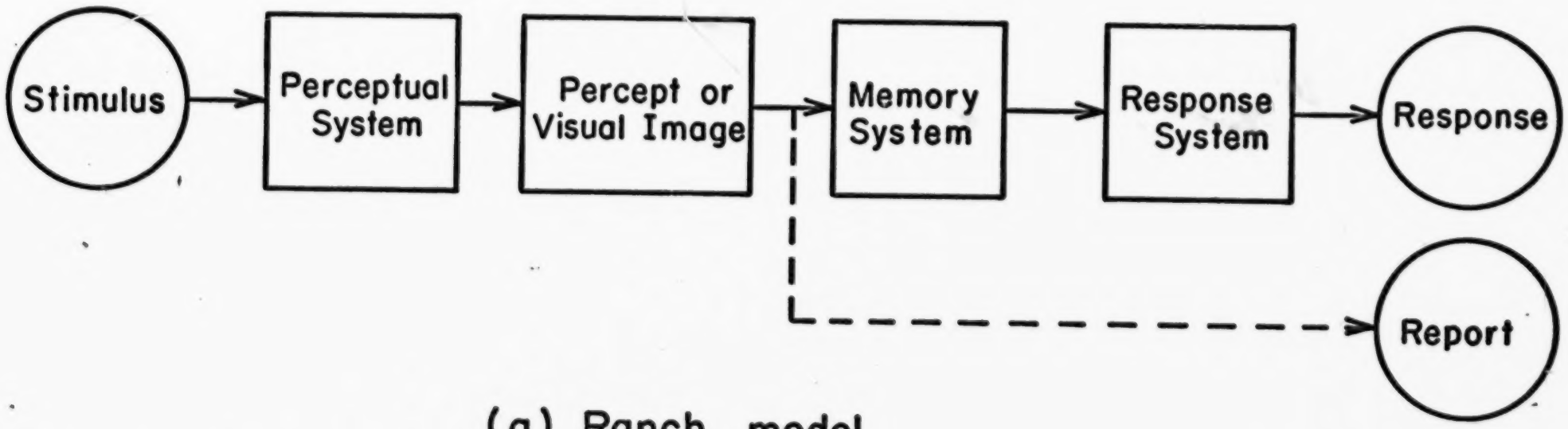
problem can be understood most easily within the framework of two architectural schemas illustrating both the conceptual problem raised by the question of locus and the methodological problem raised by the question of perceptual report. Figure 7 shows (a) the "ranch" model in which memory acts on responses only, and (b) the "split level" model in which memory acts as part of the perceptual system as well as on the responses.

In the ranch model, stimulus information is processed by the perceptual system alone, resulting in a visual image. Although memory plays no role in the processing prior to the visual image, the responses may, nonetheless, reflect the activity of memory processes since the percept must be remembered to be reported (Haber, 1968). In the split-level model stimulus information is processed by a perceptual system interacting with memory prior to the visual image. Thus the visual image itself may have properties which reflect memory processes. Since this percept also must be remembered, the flow of information must return to the memory system whence it procedes to the response.

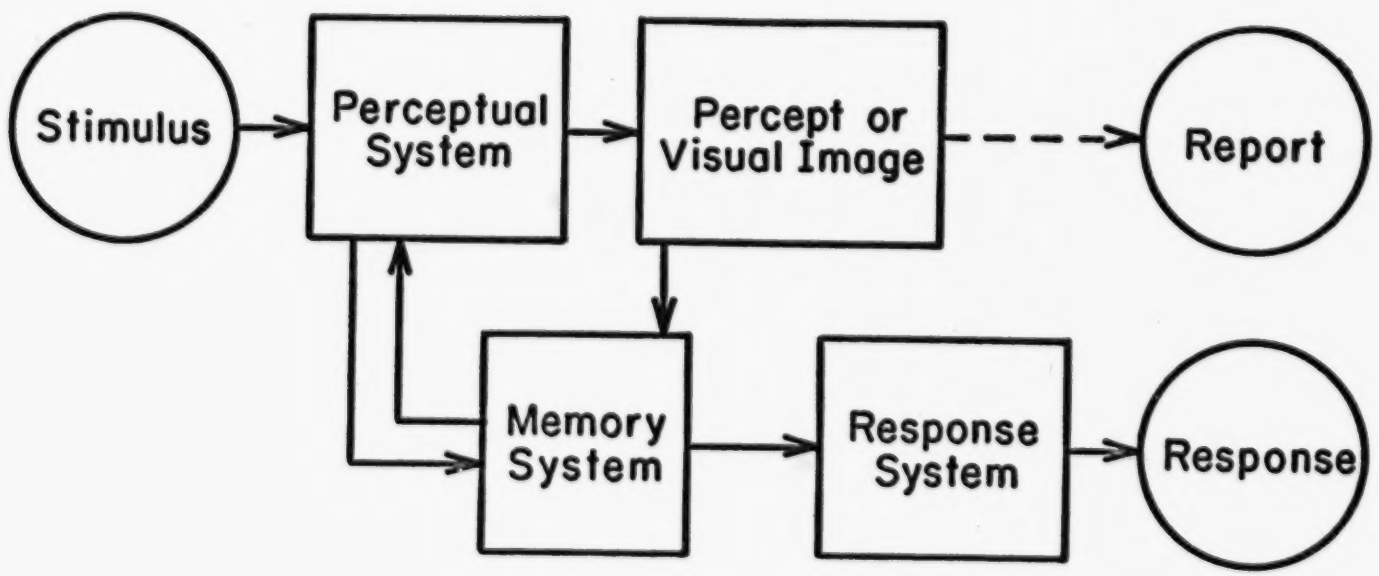
The essential difference between the two models--the position of the percept in the processing sequence--represents the schematic way of asking whether memory plays a role in determining the events that will be represented in the visual image or whether memory modifies only the report of that image. Thus from E's point of view, the models illustrate the two interpretations for sets of responses having properties attributable to memory processes: (1) they may reflect the action of post-perceptual processes--those processes involved in remembering and reporting the visual image (the ranch model), or (2) they may reflect a visual image altered by the action of memory directly within the perceptual system (the split level model).

The modification in method in the experiments is illustrated by separating from the general category of activity called "response" the particular subset called "reports" (Natsoulas, 1967). In Figure 7 this class of responses is represented by dashed arrows emerging from the boxes labeled "percept" to indicate that reports are assumed to be isomorphic with the visual image. Now it should be apparent that in the split-level model, unaltered reports of the visual image would manifest the attributes of memory, whereas in the ranch model, they would not. Thus if reports could be obtained, the locus of the effects of past experience could be determined. A major purpose of Exp. II was to obtain reports.

The models also underscore the differences between the processes of perceptual recognition and perceptual microgenesis. Recognition necessarily involves an interaction between perception and memory, and it is expected that memory will at least supplement the visual image to produce responses which match the stimuli better than those produced by the image alone. The recognition responses should, therefore, contain



(a) Ranch model



(b) Split-level model

contributions from both the visual image and the memory supplement, and the properties of the responses will reflect the activity of both systems. Perceptual microgenesis, on the other hand, is by definition a process which occurs prior to the visual image. Studies of microgenesis, therefore, are concerned only with properties of the visual image (Haber, 1966) and require for study the special class of responses called reports.

Assessment of reports.--The data indicate that reports were obtained in Exp. II, but not in Exp. I. The most convincing support for this interpretation is the difference in the shapes of the curves for perceptibility as a function of letter position (Fig. 6). Whereas this function was relatively flat in Exp. I, it was an inverted U-shaped curve in Exp. II, the shape expected for visual function--highest perceptibility around the fixation point, dropping off the farther the letter was from fixation (Crovitz and Schiffman, 1965).

The AE x P interaction lends further support to this contention. In Exp. I the interaction was large and highly differentiated, and bore little resemblance to the main effect of AE (Fig. 5). In Exp. II it was weak, hardly separable, and followed the main effect (the visual function) closely for all AEs. If the curves in Exp. II are understood as representing a visual function, then those of Exp. I can be understood as a combination of this visual function and a memory or response supplement.

The high correlation between EF and the distributions of incorrect responses (guess distributions) suggests that the visual function was supplemented by guesses (Attneave, 1953). It indicates that Ss were saying they saw letters which, in fact, they did not see, despite specific instructions not to guess. This behavior, which might be labeled "unintentional" guessing, in addition to providing incorrect responses, probably inflated the correct responses differentially according to AE as follows: The visual function from Exp. II indicates, first, that there should have been little guessing for letters near the fixation point since they had the highest probability of being perceived and, second, that guessing should have increased as a function of distance from the fixation point. Furthermore, since Ss always responded from left to right, the probability of a guess being correct should have been a decreasing function of left-right position (subject, of course, to the usual minor modifications of serial position effects), and should also have been differentiated according to AE. This combination of events could explain the complex differences between the AE x P interactions (Figs. 5 & 6) and also why the overall performance was better in Exp. I than in Exp. II.

On the other hand, it is probable that little or no guessing took place in Exp. II since there were almost no incorrect responses. Indeed, there should have been no reason for S to guess the identity of a letter in this experiment since the population of stimuli had been memorized and S knew which array would be presented on each exposure. The problem

for these Ss was whether or not they saw a particular letter, not what it was. If, despite these factors, Ss still said they saw letters which, in fact, they did not, then, indeed, the perceptibility functions would have been inflated. However, the inflation would have been uniform across AEs and the isomorphism between the report and the visual image would have been maintained.

These assumptions fit the data of the two experiments so well that the underlying assumption--that the data of Exp. II were perceptual reports--appears to be supported. The differences in the AE x P interactions between the two experiments may be taken as a clear indication that stimulus structure initiated memory processes which determined errors in responding and inflated the perceptibility functions independently of the perceptual system in Exp. I, and that these effects were almost totally absent in Exp. II. The perceptibility curves in Exp. II may, therefore, be taken as close approximations of the properties of the visual image.

Letter position.--The overriding determiner of perceptibility was letter position. In Exp. I, perceptibility appears to have been determined by an interaction of relative position in the sequence (left-right position) and position relative to the fixation point. In Exp. II it appears to have been completely determined by the latter. Except for the slight superiority of the left side, the letter position curve for Exp. II corresponds to visual anatomy. Thus perceptibility as a function of letter position may reflect relative visual acuity or, perhaps, an internal attentional mechanism for organizing input--a perceptual acuity.

In a series of experiments, Crovitz and Schiffman (1965) systematically evaluated the contributions of position in sequence and position relative to fixation point on the "reportability" of letters exposed in a tachistoscope. They required Ss to report the letters "seen" but gave them neither instructions about the stimulus array to be exposed nor special training about the population of possible stimuli. Under these conditions, reportability had little relationship to point of fixation or to variation in spacing (visual angle varied from 4^{o} 24' to 8^{o} 48') but depended almost exclusively on the relative position within the array. This finding can now be understood since the instructions in their experiments were similar to those of Exp. I. It is probable that Crovitz and Schiffman were dealing with responses which, to a large extent, reflected postperceptual processes.

Stimulus structure.--The slope of the line relating perceptibility to stimulus structure was positive--it differed significantly from zero--but the difference in perceptibility between zero-order AE (0% redundancy) and English (55% redundancy) was so small, less than 10%, that the implication must be asserted with reservation. That structure in memory enhances the percept of a stimulus which approximates that structure--that the split level model is appropriate--is suggested but not clearly demonstrated.

The linear function relating information transmitted to stimulus structure had a markedly negative slope, i.e., the amount of information transmitted through the perceptual system was a decreasing function of the redundancy of the stimulus. Now if the microgenetic task differs from the recognition task in the extent to which postperceptual processes determine the response, and if the amount of information transmitted in a recognition task is constant, as Miller, et al. (1954) and Baddeley (1964a) have shown, then the amount of information contributed by post-perceptual processes in the recognition task must be an increasing function of the stimulus structure.

The results are consistent with conceptions of the recognition response as the product of multi-stage processing (e.g., Sperling, 1963), except for the role of acoustic encoding and rehearsal. If acoustic rehearsal is part of the processing, then one should expect auditory confusions to occur with some frequency. The lack of correlation between AC and any of the other distributions in Exp. I supports the findings of Dainoff and Haber (1967) for a similar perceptual task, of Chase and Posner (1965) for a visual search (recognition) task, and of Keele and Chase (1967) for a visual short-term memory task, which suggest that, in general, acoustic encoding plays a minimal role in visual tasks. Perhaps acoustic coding is invoked only when the percept is ambiguous or unknown.

Repeated exposures.--The increase in perceptibility over repeated exposures found in Exp. I was similar to that found in a number of other studies (Haber, 1966, 1967). The attenuation of the effect in Exp. II, essentially a difference between the first and second exposures, raises the question of the extent to which repeated exposures affect perceptibility. There appears to be no reason to doubt that, at the least, perceptibility is greater for a second exposure of the same seven-letter array regardless of its structural characteristics. The obvious alternative explanations have apparently been ruled out since guessing and surprise were eliminated. It is probable, therefore, that the attenuation reflected the clearing away of responses which were initiated in postperceptual processes.

This explanation raises the question of the degree to which post-perceptual processes initiated responses in previous studies of perception as a function of repeated exposures. Unintentional guessing can occur even when intentional guessing has been eliminated and it is likely to be manifest when S knows what the stimulus was but has to decide how much of it he saw. For example, in an experiment in which each of one group of English words was shown to S immediately prior to the first exposure and a second group of words was not so exposed, Haber (1965) found that perceptibility was greater when S was given prior knowledge of the stimulus word. If unintentional guessing was present in both conditions, there would be little chance of adding correct responses for the stimulus unknown group, but a great chance of adding correct responses for the prior knowledge group. The percentage of letters correctly reported for known words should, therefore, be greater than for unknown words.

The E x P interaction in Exp. II--the decline in performance for the left-hand positions and the increase in right-hand positions with repeated exposures--may indicate that attention shifted with additional exposures. That is, Ss may have focused attention on the left over the first three exposures and then shifted to the right. This did not alter the overall percentage of letters perceived after the second exposure, however, nor the shape of the curve for letters correct over letter position.

Experiment III

It has already been seen, in Exp. II, that perceptibility increases only slightly as a function of stimulus structure for Ss who have memorized the population of letter arrays to be used as stimuli and who know what the particular array will be on a given exposure. This experiment is intended to clarify the nature of this increase in perceptibility: to determine whether it is indeed perceptual or whether it may be attributed to postperceptual processes whose nature has yet to be determined. An indicator method will be used to minimize the contribution from post-perceptual processes to each response since this method requires S to reply only with the single letter indicated.

Method

Stimuli.--The stimuli were 70 7-letter arrays, 14 of each of zero-, first-, second-, and third-order approximation to English (AE), and 14 English words. These lists included one additional array to each of the lists in Exp. II. Each array was lettered in black on a white card with a LeRoy stencil No. 3240-240C and pen No. 3233-5. The 2 7/8 x 1/4 in. stimulus field was divided into 13 equal areas to contain letters separated by six spaces. The stimuli subtended a horizontal visual angle of 3 1/2°.

Procedure.--Stimuli were flashed in one channel of a three-channel mirror tachistoscope. An indicator marker-a small vertical line of light presented in a second channel of the tachistoscope-appeared to S to be 1/8 in. above the indicated letter and informed S which letter to report. The indicator was presented in one of two conditions: concurrently (C) with the letter array, i.e., both stimulus field and indicator field flashed at the same time or successively (S), i.e., the indicator field flashed upon termination of the stimulus field.

The Ss were divided into three groups: Naive-Guess (NG), Naive-No Guess (NNG), and Trained (TR). Subjects in both naive groups knew nothing about the letter arrays before they were flashed. The TR Group memorized the list of arrays to be shown and, in addition, saw

and were required to spell to E the word that would be flashed. NNG and TR Ss were instructed to report only those letters they were certain they had seen; NG Ss were required to respond even when they did not see a letter. The latter condition provides a comparison with other experiments using the indicator methodology since most experimenters require Ss to guess the letter in the indicated position.

Arrays of seven letters were flashed once each so that each of the seven letter positions could be sampled. Each cell of the 70-cell letter position (P) x treatments (T) x approximation to English (AE) matrix was sampled once for each S.

Results

Table 1 shows the results of a four-way factorial analysis of variance. All four main effects are significant: Groups (G), stimulus structure (AE), treatments (T), and letter position (P). The interactions of P X G and A X T were also significant.

Stimulus Structure.--The increase in perceptibility as a function of stimulus structure was significant, but small, as in the previous experiment (Fig. 8). The interaction of stimulus structure with treatments, although significant, was slight and uninterpretable.

Training.--There was a large effect on training or instruction. The TR group saw many more letters than others; the NG group did only slightly better than the NNG group. While the interaction of letter position was significant the differential effect did not appear striking (Fig. 9).

Letter Position.--Main effect of letter position again was the most marked effect yielding an inverted U-shaped function with the left side better than the right side. There was an inversion of positions 6 and 7 which would be due to masking. The curve for the NNG group in the position by group interaction (Fig. 9) appears to be a visual function, i.e., an inverted U-shaped curve with no upturning at the ends and rather symmetrical. The NG group showed a similar curve with upturned ends and a greater left-right difference. The curve given by the TR Group showed a superior left side and an inversion between positions 6 and 7.

Discussion

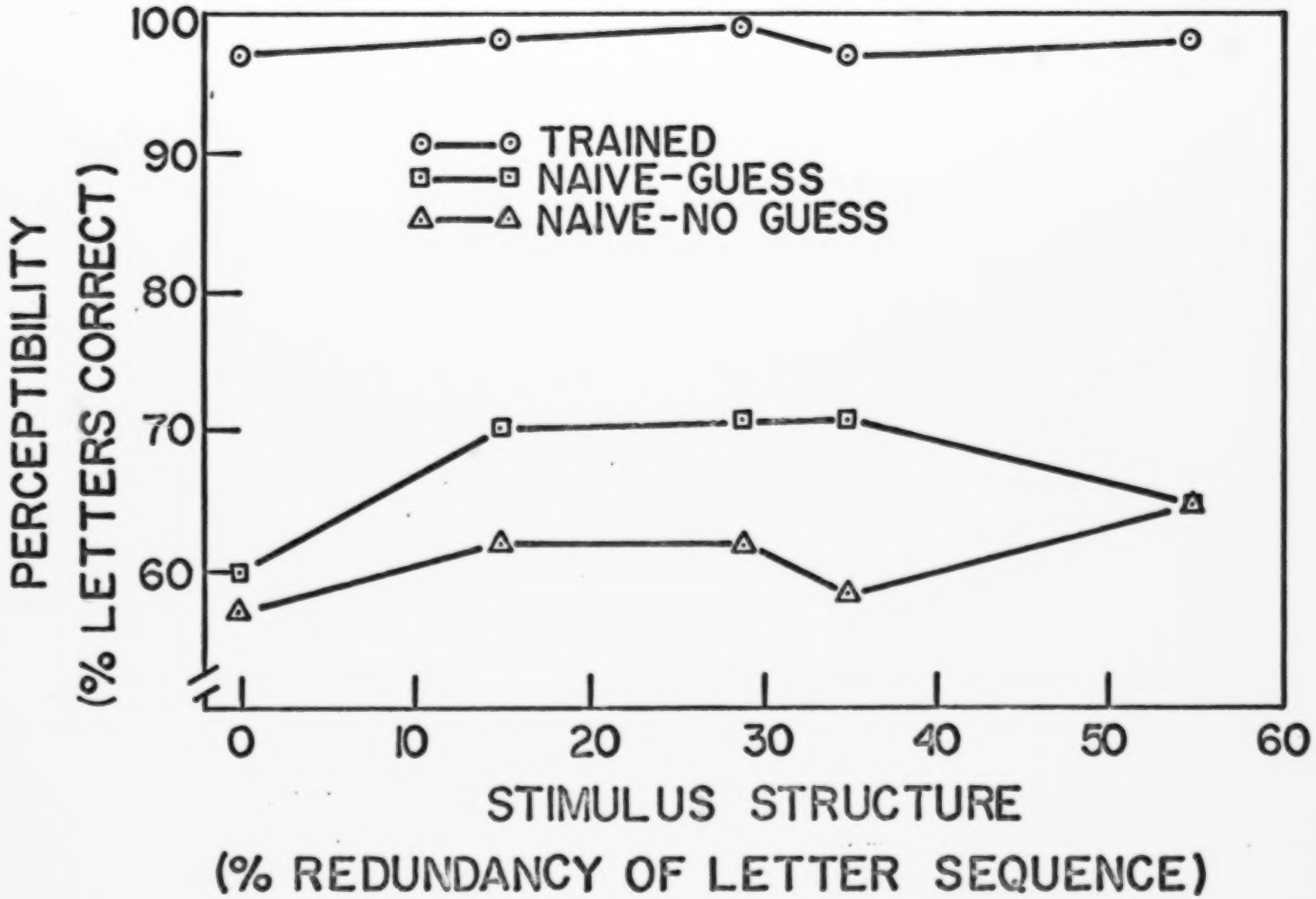
Sampling from the percept by means of an indicator reduces the probability that postperceptual processes modified the report of the

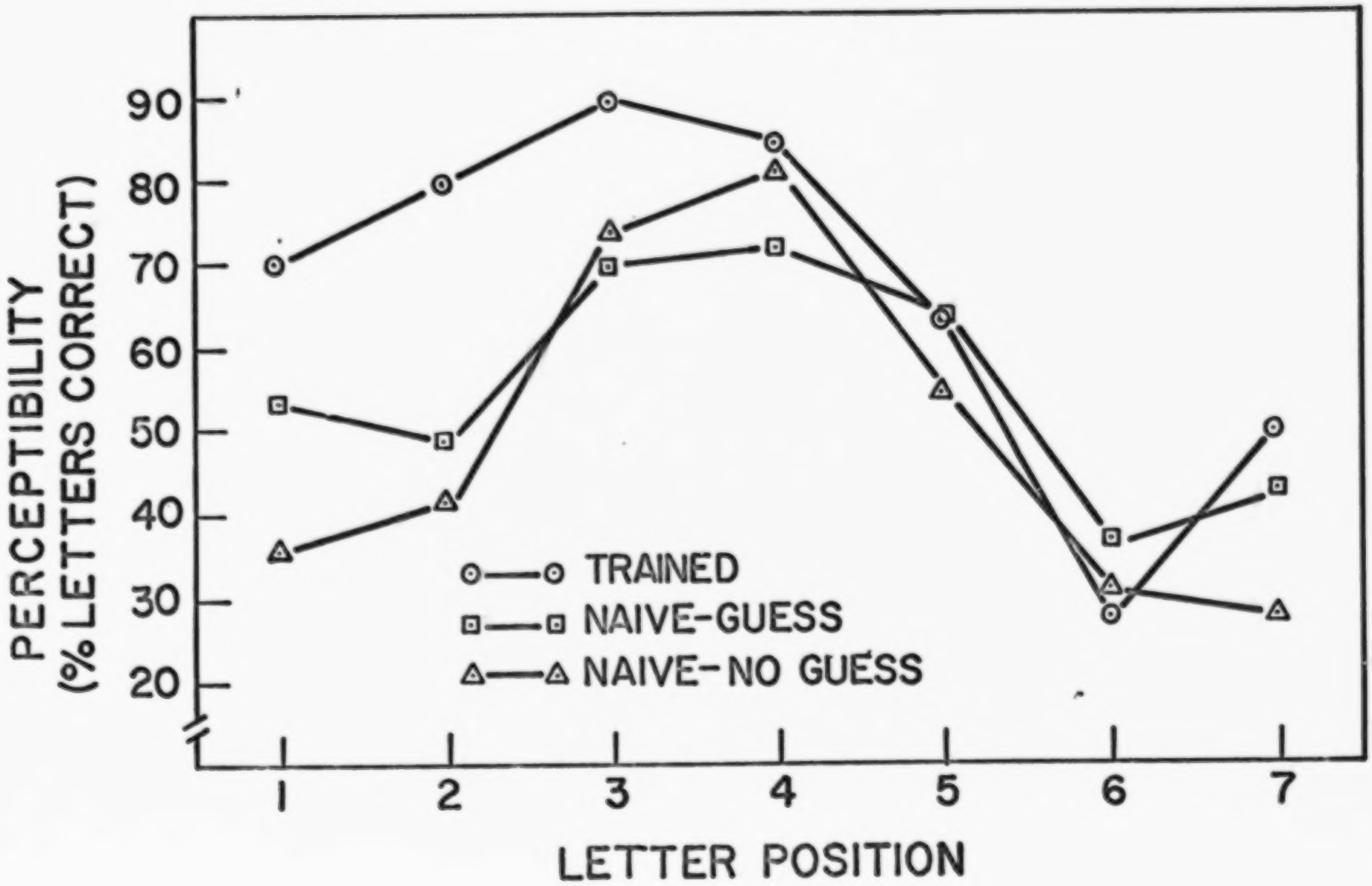
TABLE 1

Analysis of Variance on Number of Letters Reported Correctly in Indicator Study

Source		df	MS	Error Term	F
Groups (G)		2	65.661	(1)	5.10*
Stimulus Structure (AE)		4	6.042	(2)	5.27**
Treatments (T)		1	9.910	(3)	7.88*
Letter Position (P)		6	117.028	(4)	25.35**
AE x G		8	.731	(2)	.64
T x G		2	.046	(3)	.04
P x G		12	10.289	(4)	2.23*
AE x T		4	1.732	(5)	2.76*
AE x P		24	.875	(6)	.99
T x P		6	.537	(7)	.63
AE x T x G		8	1.052	(5)	1.67
AE x P x G		48	.971	(6)	1.10
T x P x G		12	.465	(7)	.55
AE x T X P		24	.758	(8)	.87
AE x T x P x G		48	.780	(8)	.90
S(G)	(1)	12	12.875		
AE x S(G)	(2)	48	1.146		
T x S(G)	(3)	12	1.257		
P x S(G)	(4)	72	4.616		
AE x T x S(G)	(5)	48	.628		
AE x P x S(G)	(6)	288	.884		
T x P x S(G)	(7)	72	.849		
AE x T x P x S(G)	(8)	288	.871		

*P < .05
**P < .01


100
90
80
70
60
TRAINED
NAIVE-GUESS
NAIVE-NO GUESS
PERCEPTIBILITY
(% LETTERS CORRECT)
0
10
20
30
40
50
60
STIMULUS STRUCTURE
(% REDUNDANCY OF LETTER SEQUENCE)


PERCEPTIBILITY
(% LETTERS CORRECT)
90
80
70
60
50
40
30
20
TRAINED
NAIVE-GUESS
NAIVE-NO GUESS
1
2
3
4
5
6
7
LETTER POSITION

percept. Thus, both the increase in the percentage of letters correctly reported as a result of guessing (intentional or unintentional) and the decrease in the percentage of letters correctly reported due to forgetting, should have been eliminated. When an indicator is flashed simultaneously with a letter array, or immediately following an array, S must remember only the single letter, presumably not a great burden on his memory. There should be little forgetting in this case, if, indeed, the stimulus were perceived.

The shape of the letter position curve for the NNG group suggests that these responses were more nearly isomorphic to the visual image then those of the other groups. Accordingly, the effects of stimulus structure on perception should be evaluated from the results of this group. This group gave results which are consistent with those of Exp. II: a slight increase in perceptibility as a function of stimulus structure. In fact, the slope of the line of best fit was 0.09, very close to that obtained in the previous study.

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